What is the Ohm Pattern?

Brief Overview:

Ohm's law is a standard part of middle school science curriculum. However this unit employs a thematic cross-curricular constructionist approach to this basic concept. Ideally, both the math and science teachers will be involved. A lesson may be done in either the math or science class or teachers may wish to combine classes to have a longer module period.

The unit encompasses building electrical circuits, writing equations, and graphing This unit is best done before or during the electricity unit of science class, as students should **not** already know the relationship between the variables of Ohm's Law.
The students will build circuits, observe the effects of manipulating variables, and induce a possible formulaic explanation for their observations, and then conclude by producing data tables for others to deduce the formula.

NCTM Content Standard

Algebra

Instructional programs from prekindergarten through grade 12 should enable all students to--

- understand patterns, relations, and functions;
- represent and analyze mathematical situations and structures using algebraic symbols;
- use mathematical models to represent and understand quantitative relationships;
- analyze change in various contexts.

Communication

Instructional programs from prekindergarten through grade 12 should enable all students to--

- organize and consolidate their mathematical thinking though communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely.

National Science Education Content Standards (Grades 5-8):

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science

- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

Grade/Level: 5^{th} - 8^{th}

Duration/Length: Three 60 - 90 minute modules

Student Outcomes:

Students will:

- Determine the relationship between 2 variables by identifying patterns in data set
- Write an equation based on recognized patterns in data set.
- Create an equation and complete a data table of values to satisfy the equation.
- Apply relationship identification to deduce Ohm's law of electricity.

Materials and Resources:

Lesson 1	Teacher Resource Sheets, Student Resource Sheets Per group/student – 1 flashlight bulb, 1 paperclip, 1 D battery
Lesson 2	Teacher Resource Sheets, Student Resource Sheets TI-83 Plus, TI-83, or TI-73** CBL-2 or LabPro data collection device **
Lesson 3	Teacher Resource Sheets, Student Resource Sheets

** These devices may be borrowed from Texas Instruments for a 14-day period. For more information call 1-888-282-8233 or access their web site at http://education.ti.com/

Development/Procedures:

Lesson 1

Objective

- Students will build an electrical circuit.

Pre-assessment and Launch

- Give students 10 minutes to light a flashlight bulb with a battery and paper clip. Have successful students demonstrate how they lit the bulb.

Teacher Facilitation

This component may be completed via video presentation, instruction in science class, or

- Overview basic components of electricity current through electrical appliances (Teacher Resource # 1).

- Work with the students to build their understanding of the concept, introducing concepts of resistance, voltage and current.

- Teacher then demonstrates how current, resistance, and voltage are both adjusted and measured.

Student Application

- Build a circuit – implore the assistance of your science teacher.
- Allow students to partner with another student and in cooperative groups build the circuit. (Student Resource # 1A)
- Upon completion, all students should complete the newspaper article activity (Teacher Resource # 2 and Student Resource # 2).

Embedded Assessment

- Newspaper Article - What a Shock!
- Student monitoring
- Observation of final product

Re-teaching/Extension

- Think, Pair, Share –
  For students who do not satisfactorily complete What a Shock!, place the students in cooperative groups and review electricity concepts allowing students to answer questions of "Did You Feel The Shock !" (Teacher Resource # 3)

- For a challenge, have students investigate parallel and series circuits. If time permits, allow them to build an example of each.

Lesson 2

Pre-assessment

- Name the components of an electrical circuit and/or
- What is the relationship between column A and column B?
    - Select a value for A. What is B?
    - What equation can represent this relationship? (B=A/2)

A	B
4	2
6	3
8	4
10	5

Launch

- Give students a set time period to work either individually or alone to invent a machine to measure voltage, resistance, or current of a circuit. Allow them to draw a prototype of their invention and select a few to present to the class.

Teacher Facilitation

- If materials are available, teacher demonstrates how current, resistance, and voltage are both adjusted and measured.

- If no equipment is available, you may substitute values that satisfy Ohm's Law and allow students to work from a pre-created data table rather than creating a data table.

- There are a variety of methods to be used, select what is most accessible to your school based on available resources.
    - Texas Instruments CBL 2's (Computer Based Laboratory) with voltage probes
    - Traditional Ammeter, and Voltmeter, millimeter, etc.

Student Application

- Divide and assign students to different groups circuits. Each circuit should have a different form of Student Resource # 3.
- Have the students complete table and construct the graph. A graphing calculator may be used instead of paper.
- Have them deduce a formula that would be consistent with their circuit observations.
- Discuss Ohm's Law as the consistent relationship between 3 variables.

Embedded Assessment

Student Resource # 4 – Equation-mania

Re-teaching/Extension

- Have students create single operation equations and the corresponding data table and solve one another’s.
- Allow students to create equations with 3 operations and the corresponding data table, and solve one another’s.

Lesson 3

Pre-assessment and Launch

- Ask students who has seen, read, or heard a biography in the last month. Have students share some responses. What are 5 aspects of a biographical feature?

Teacher Facilitation

- Teacher will share a biography of Georg Simon Ohm.

Student Application

- Students will select a mathematician to write a biographical feature from a prepared list

Embedded Assessment

- Rubric devised by teacher to stress the features desired.

Re-teaching/Extension

- Have students write a biography about themselves dated 20 years from present.

Summative Assessment:

Create a children's storybook about electricity and Ohm's Law.

Author:

Natasha Spence
Gwynn Park Middle School
Prince George's County

Student Resource # 1

Building a Circuit

Using the materials given in your packet, assemble the circuit.

Student Resource # 2

What a Shock!!!

Write a newspaper article for your school's newspaper. The headline of the article is

"STUDENT RECEIVES AN ELECTRIC SHOCK IN SCIENCE CLASS!"

In your article describe what may have occurred in the circuit to give the student a shock. Be sure to describe the functions of all parts of a circuit.

Student Resource # 3 - Without measuring apparatus

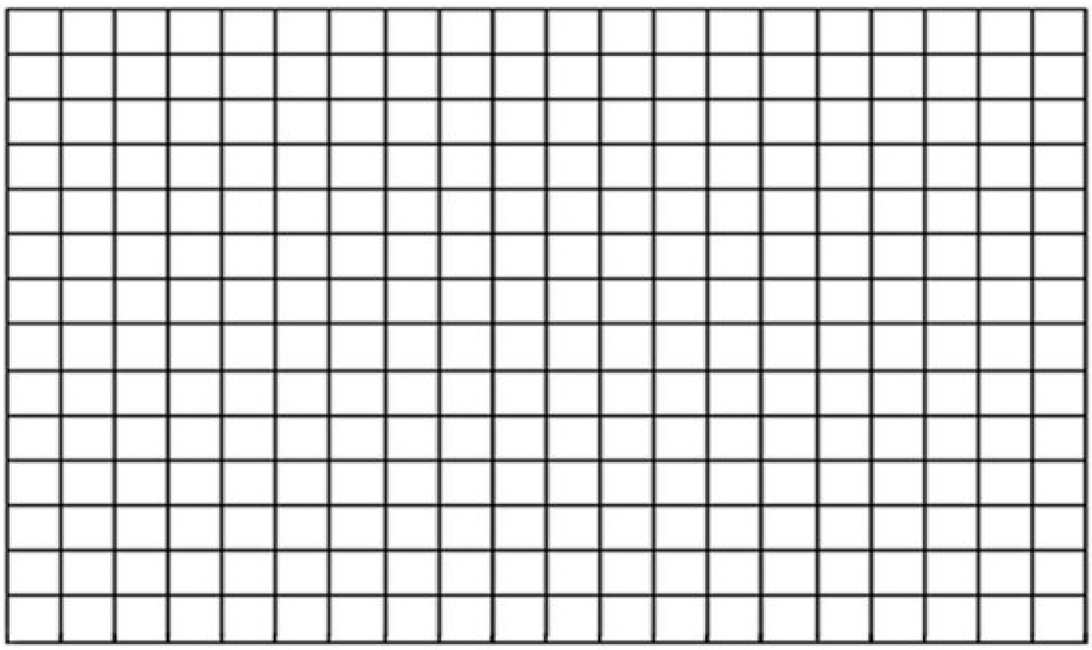
Current ( )	Voltage ( )	Resistance ( )
0.16	12	75
15	240	16
5.5	110	20
5	110	22
0.24	6	25

Graph

Name: ______________________________ Date: _________ Per. ________

Resistance	Voltage	Current
2200	110	
1800	110	
1400	110	
1000	110	
800	110	
500	110	
100	110	

Graph



Name: ______________________________ Date: _________ Per. ________

Voltage	Current	Resistance
	10	
	10	
	10	
	10	
	10	
	10	
	10	

Graph

Name: ______________________________ Date: _________ Per. ________

Current	Resistance	Voltage
0.1	40	
1.1	40	
2.1	40	
3.1	40	
4.1	40	
5.1	40	
6.1	40	

Graph

Student Resource # 4
Use the data tables below to write an equation.

Equation-Mania

1.

a	b
4	3
6	4
8	5
10	6

2.

a	b
mazda	mzd
honda	hnd
volvo	vlv
bmw	bmw

3.

a	b
Wendys	sydnew
Taco bell	llebocat
Burger King	gnikregrub
Subway	yawbus

4.

a	b
1	1
2	4
3	7
4	10

5.

a	b	c
1	1	1
2	2	1
3	3	1
4	4	1

6.

a	b	c
Apples	Pples	a
Oranges	Oranges	e
Kiwi	Kw	I
Melon	Meln	o
Guava	Gava	u

7.

a	b	c
3	5	15
6	4	24
10	3	30
13	2	26
15	1	15

8.

x	y
15	6
50	13
5	4
20	7
500	103

Teacher Resources #1

Electricity Overview

When you made the battery light the bulb a complete path through which charge flows is formed. This path is known as a **circuit**. It is complete and closed.

The rate at which charge flows through the bulb are wire/paperclip is called **electric current**. Current is how much electric charge flows past a point in a circuit during a given time. It is measured in amperes (A).

Current flows whenever there is a potential difference between the ends of a wire. The size of the potential difference determines the current that will flow through the wire. The greater the potential difference the faster the charges will flow. Potential difference is measure in volts (V) and is called **voltage**.

The amount of current that flows through a wire does not depend only on the voltage. It also depends on how the wire resists the flow of electrical charge. Opposition to the flow of electric charge is known as **resistance (R)**. The unit for resistance is **ohms**.

Internet-based resources

http://quarknet.fnal.gov/projects/ohms/student/bkgrd.shtml

http://www.learnnc.org/learnnc/lessonp.nsf/0/FBFC8639A3DA63D4852568F10054B7A9?openDocument

http://www.learnnc.org/learnnc/lessonp.nsf/0/FBFC8639A3DA63D4852568F10054B7A9?openDocument

http://www.gordon.army.mil/stt/31c/B04LP1.html

http://www.sasked.gov.sk.ca/docs/physics/u3b33phy.html

Teacher Resource # 2

What a Shock!!!

Write a newspaper article for your school's newspaper. The headline of the article is

"STUDENT RECEIVES AN ELECTRIC SHOCK IN SCIENCE CLASS!"

In your article describe what may have occurred in the circuit to give the student a shock, be sure to describe the functions of all parts of a circuit.

Teacher Resource #3

Did you feel the shock!!

1. What must occur for a person to experience an electric shock?
2. Name the 3 parts of an electric circuit.
3. What is current and its unit of measurement?
4. What is voltage and its unit of measurement?
5. What is resistance and its unit of measurement?
6. Give an example of an appliance utilizing all the circuit components?
7. Have you ever felt a shock?

Teacher Resource # 4

Equation- Mania

1. a/2 + 1 = b
2. a – vowel = b
3. a in reverse = b
4. 3a – 2 = b
5. c = a/b
6. a – c = b
7. a x b = c
8. x/5 + 3 = y

Teacher Resource #5

Online resources for biographical information on multicultural mathematicians

Women mathematicians
http://www.agnesscott.edu/lriddle/women/women.htm

Multicultural mathematicians
http://www-groups.dcs.st-and.ac.uk/~history/Indexes/HistoryTopics.html

Mathematics in various cultures

Ancient Babylonian mathematics

Ancient Egyptian mathematics

Ancient Greek mathematics

Indian mathematics

Arabic mathematics

Mayan mathematics

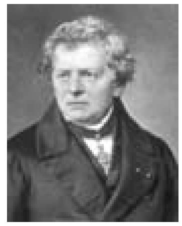
American mathematics

Mathematics in Scotland

Georg Simon Ohm

Born: 16 March 1789 in Erlangen, Bavaria (now Germany)

Died: 6 July 1854 in Munich, Bavaria, Germany



Click the picture above
to see two larger pictures

Show birthplace location

Previous	(Chronologically)	Next	Biographies Index
Previous	(Alphabetically)	Next	Main index

Georg Simon Ohm came from a Protestant family. His father, Johann Wolfgang Ohm, was a locksmith while his mother, Maria Elizabeth Beck, was the daughter of a tailor. Although his parents had not been formally educated, Ohm's father was a rather remarkable man who had educated himself to a high level and was able to give his sons an excellent education through his own teachings. Had Ohm's brothers and sisters all survived he would have been one of a large family but, as was common in those times, several of the children died in their childhood. Of the seven children born to Johann and Maria Ohm only three survived, Georg Simon, his brother Martin who went on to become a well-known mathematician, and his sister Elizabeth Barbara.

When they were children, Georg Simon and Martin were taught by their father who brought them to a high standard in mathematics, physics, chemistry and philosophy. This was in stark contrast to their school education. Georg Simon entered Erlangen Gymnasium at the age of eleven but there he received little in the way of scientific training. In fact this formal part of his schooling was uninspired stressing learning by rote and interpreting texts. This contrasted strongly with the inspired instruction that both Georg Simon and Martin received from their father who brought them to a level in mathematics which led the professor at the University of Erlangen, Karl Christian von Langsdorf, to compare them to the Bernoulli family. It is worth stressing again the remarkable achievement of Johann Wolfgang Ohm, an entirely self-taught man, to have been able to give his sons such a fine mathematical and scientific education.

In 1805 Ohm entered the University of Erlangen but he became rather carried away with student life. Rather than concentrate on his studies he spent much time dancing, ice skating and playing billiards. Ohm's father, angry that his son was wasting the educational opportunity that he himself had never been fortunate enough to experience, demanded that Ohm leave the university after three semesters. Ohm went (or more accurately, was sent) to Switzerland where, in September 1806, he took up a post as a mathematics teacher in a school in Gottstadt bei Nydau.

Karl Christian von Langsdorf left the University of Erlangen in early 1809 to take up a post in the University of Heidelberg and Ohm would have liked to have gone with him to Heidelberg to restart his mathematical studies. Langsdorf, however, advised Ohm to continue with his studies of mathematics on his own, advising Ohm to read the works of Euler, Laplace and Lacroix. Rather reluctantly Ohm took his advice but he left his teaching post in Gottstadt bei Nydau in March 1809 to become a private tutor in Neuchâtel. For two years he carried out his duties as a tutor while he followed Langsdorf's advice and continued his private study of mathematics. Then in April 1811 he returned to the University of Erlangen.

His private studies had stood him in good stead for he received a doctorate from Erlangen on 25 October 1811 and immediately joined the staff as a mathematics lecturer. After three semesters Ohm gave up his university post. He could not see how he could attain a better status at Erlangen as prospects there were poor while he essentially lived in poverty in the lecturing post. The Bavarian government offered him a post as a teacher of mathematics and physics at a poor quality school in Bamberg and he took up the post there in January 1813.

This was not the successful career envisaged by Ohm and he decided that he would have to show that he was worth much more than a teacher in a poor school. He worked on writing an elementary book on the teaching of geometry while remaining desperately unhappy in his job. After Ohm had endured the school for three years it was closed down in February 1816. The Bavarian government then sent him to an overcrowded school in Bamberg to help out with the mathematics teaching.

On 11 September 1817 Ohm received an offer of the post of teacher of mathematics and physics at the Jesuit Gymnasium of Cologne. This was a better school than any that Ohm had taught in previously and it had a well equipped physics laboratory. As he had done for so much of his life, Ohm continued his private studies reading the texts of the leading French mathematicians Lagrange, Legendre, Laplace, Biot and Poisson. He moved on to reading the works of Fourier and Fresnel and he began his own experimental work in the school physics laboratory after he had learnt of Oersted's discovery of electromagnetism in 1820. At first his experiments were conducted for his own educational benefit as were the private studies he made of the works of the leading mathematicians.

The Jesuit Gymnasium of Cologne failed to continue to keep up the high standards that it had when Ohm began to work there so, by 1825, he decided that he would try again to attain the job he really wanted, namely a post in a university. Realising that the way into such a post would have to be through research publications, he changed his attitude towards the experimental work he was undertaking and began to systematically work towards the publication of his results [1]:-

> *Overburdened with students, finding little appreciation for his conscientious efforts, and realising that he would never marry, he turned to science both to prove himself to the world and to have something solid on which to base his petition for a position in a more stimulating environment.*

In fact he had already convinced himself of the truth of what we call today "Ohm's law" namely the relationship that the current through most materials is directly proportional to the potential difference applied across the material. The result was not contained in Ohm's firsts paper published in 1825, however, for this paper examines the decrease in the electromagnetic force produced by a wire as the length of the wire increased. The paper deduced mathematical relationships based purely on the experimental evidence that Ohm had tabulated.

In two important papers in 1826, Ohm gave a mathematical description of conduction in circuits modelled on Fourier's study of heat conduction. These papers continue Ohm's deduction of results from experimental evidence and, particularly in the second, he was able to propose laws which went a long way to explaining results of others working on galvanic electricity. The second paper certainly is the first step in a comprehensive theory which Ohm was able to give in his famous book published in the following year.

What is now known as Ohm's law appears in this famous book *Die galvanische Kette, mathematisch bearbeitet* (1827) in which he gave his complete theory of electricity. The book begins with the mathematical background necessary for an understanding of the rest of the work. We should remark here that such a mathematical background was necessary for even the leading German physicists to understand the work, for the emphasis at this time was on a non-mathematical approach to physics. We should also remark that, despite Ohm's attempts in this introduction, he was not really successful in convincing the older German physicists that the mathematical approach was the right one. To some extent, as Caneva explains in [1], this was Ohm's own fault:-

> *... in neither the introduction nor the body of the work, which contained the more rigorous development of the theory, did Ohm bring decisively home either the underlying unity of the whole or the connections between fundamental assumptions and major deductions. For example, although his theory was conceived as a strict deductive system based on three fundamental laws, he*

nowhere indicated precisely which of their several mathematical and verbal expressions he wished to be taken as the canonical form.

It is interesting that Ohm's presents his theory as one of contiguous action, a theory which opposed the concept of action at a distance. Ohm believed that the communication of electricity occurred between "contiguous particles" which is the term Ohm himself uses. The paper [8] is concerned with this idea, and in particular with illustrating the differences in scientific approach between Ohm and that of Fourier and Navier. A detailed study of the conceptual framework used by Ohm in formulating Ohm's law is given in [6].

As we described above, Ohm was at the Jesuit Gymnasium of Cologne when he began his important publications in 1825. He was given a year off work in which to concentrate on his research beginning in August 1826 and although he only received the less than generous offer of half pay, he was able to spend the year in Berlin working on his publications. Ohm had believed that his publications would lead to his receiving an offer of a university post before having to return to Cologne but by the time he was due to begin teaching again in September 1827 he was still without such an offer.

Although Ohm's work strongly influenced theory, it was received with little enthusiasm. Ohm's feeling were hurt, he decided to remain in Berlin and, in March 1828, he formally resigned his position at Cologne. He took some temporary work teaching mathematics in schools in Berlin.

He accepted a position at Nüremberg in 1833 and although this gave him the title of professor, it was still not the university post for which he had strived all his life. His work was eventually recognised by the Royal Society with its award of the Copley Medal in 1841. He became a foreign member of the Royal Society in 1842. Other academies such as those in Berlin and Turin elected him a corresponding member, and in 1845 he became a full member of the Bavarian Academy.

This belated recognition was welcome but there remains the question of why someone who today is a household name for his important contribution struggled for so long to gain acknowledgement. This may have no simple explanation but rather be the result of a number of different contributary factors. One factor may have been the inwardness of Ohm's character while another was certainly his mathematical approach to topics which at that time were studied in his country a non-mathematical way. There was undoubtedly also personal disputes with the men in power which did Ohm no good at all. He certainly did not find favour with Johannes Schultz who was an influential figure in the ministry of education in Berlin, and with Georg Friedrich Pohl, a professor of physics in that city.
Electricity was not the only topic on which Ohm undertook research, and not the only topic in which he ended up in controversy. In 1843 he stated the fundamental principle of physiological acoustics, concerned with the way in which one hears combination tones. However the assumptions which he made in his mathematical derivation were not totally justified and this resulted in a bitter dispute with the physicist August Seebeck. He succeeded in discrediting Ohm's hypothesis and Ohm had to acknowledge his error. See [10] for details of the dispute between Ohm and Seebeck.
In 1849 Ohm took up a post in Munich as curator of the Bavarian Academy's physical cabinet and began to lecture at the University of Munich. Only in 1852, two years before his death, did Ohm achieve his lifelong ambition of being appointed to the chair of physics at the University of Munich.

Article by: *J J O'Connor* and *E F Robertson*